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DWARFMISTLETOES OF CALIFORNIA AND THEIR CONTROL

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By James W. Kimmey

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THE DWARFMISTLETOES OF CALIFORNIA AND THEIR CONTROL

By James W. Kimmey [1]

Losses caused by the dwarfmistletoes in California's coniferous forests rank next to losses from heart rots. In the future when the overmature virgin stands have been largely cut over, these parasitic plants, if not controlled, may be far more damaging than fungi. Although damage from dwarfmistletoes has long been recognized here, the extent and magnitude of the losses have not been generally known until recent years. It is now recognized that the reduction of damage caused by these parasites is the most important problem in applied forest pathology in the State.

Because foresters have not appreciated the potential threat of dwarfmistletoes, little has been done to work out a concerted control program for young coniferous stands. To provide impetus to a control program, foresters should have a general understanding of the parasites, how they function, and how they may be controlled.

The purpose of this paper is to provide a summary of essential facts regarding the dwarfmistletoes and their control.

SPECIES AND FORMS

The dwarfmistletoes are seed-bearing plants belonging to the genus _Arceuthobium_ that are parasitic on most western conifers. Based on anatomical characteristics, there are three species in California; one of them includes seven forms, with different host susceptibility relationships. In general the various species and forms are confined to a definite host or group of hosts, but transfers from one host species or genus to another occur now and then.

The species and forms occurring in California and their tree hosts are:

1. Lodgepole pine dwarfmistletoe: _A. americanum_, common on the mountain form of lodgepole pine but seldom attacking the coast form. Occasionally it may occur on other pines when these are associated with infected lodgepole pines.

2. Douglas-fir dwarfmistletoe: _A. douglasii_, confined to and common on Douglas-fir.

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3. Western dwarfmistletoe: A. campylopodum, divided into a number of host forms:

    a. forma campylopodum (figs. 1, 2, 3, and 4) occurs on Coulter, digger, Jeffrey, Monterey, and ponderosa pines but is rare on knobcone and lodgepole pines;

    b. forma divaricatum occurs on pinyons;

    c. forma cyanocarpum on bristlecone, foxtail, limber, and whitebark pines;

    d. forma blumeri on sugar and western white pines;

    e. forma abietinum on lowland white, red, and white firs;

    f. forma tsugensis on mountain and western hemlocks;

    g. forma microcarpum on weeping spruce.

THE PARASITE PLANT

The plants of the dwarfmistletoes are quite similar in all species except those of A. douglasii, which are especially small, usually being 1/4 to 3/4 inch in length. Even in the largest species, however, the shoots rarely attain a length of 8 inches.

Aerial Shoots

The aerial parts appear as perennial shoots, either simple or branched (figs. 1 and 2). Usually they occur in tufts, but the aerial parts of A. douglasii and occasionally those of other species are scattered along the young twigs of the host. They are jointed, with opposite pairs of scale-like leaves at the top of each segment. The segments are four-sided at the base and are usually angular throughout but may be round at the upper end. The color varies from yellowish to brownish green or olive green in many shades.

Seed Production

The male and female flowers are produced on separate plants (figs. 1 and 2). A. americanum and A. douglasii bloom in the spring; A. campylopodum in late summer. The berries (fig. 2) mature the second autumn after pollination. After flowering, the male shoots die as do the female shoots after the seeds are discharged.

Birds and animals do not eat the seeds; therefore they are of no significance in the spread of the dwarfmistletoe plants.

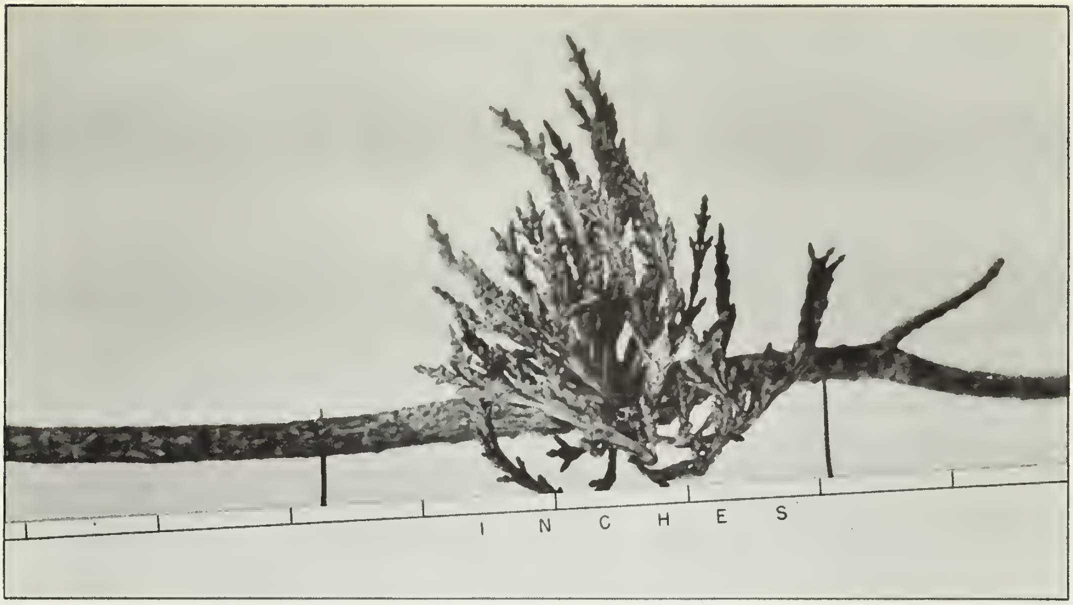

Figure 1.--Typical young male plant of western dwarfmistletoe on a pine branch.

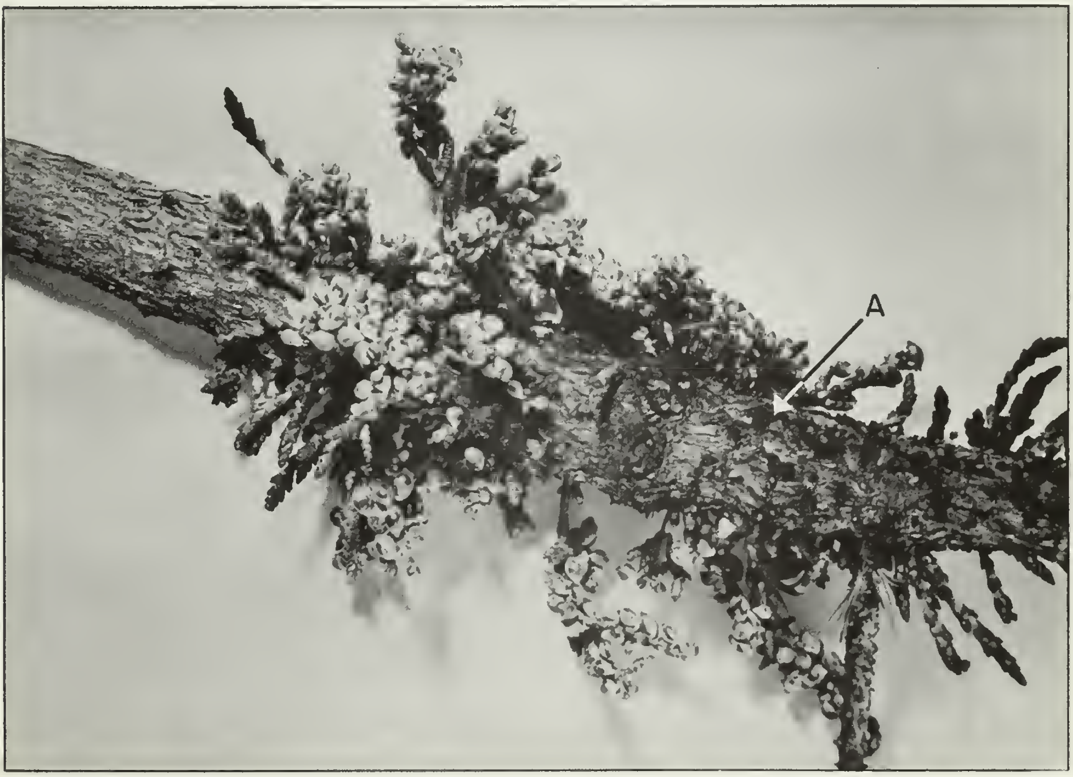

Figure 2.--Female plant of western dwarfmistletoe producing berries. Pine branch shows typical spindle-shaped swelling or canker. A. Basal "cups" from which shoots of the parasite have dropped.

Seed Dissemination

On ripening, the berries develop a considerable internal pressure, which increases until any slight disturbance causes them to explode and eject the seed with some force. This explosive ejection of the seed is the means by which the parasite is spread. Because of the position of the berries, the seeds are usually shot upward and arch outward. The maximum lateral distance travelled by seed of lodgepole pine dwarfmistletoe in a laboratory test was 33 feet.

Wind during the berry ripening period affects the distance and pattern of spread. Wind is one of the principal sources of the mechanical jarring that triggers seed ejection. Wind is responsible for the oval pattern of seed distribution below a tall tree, the axis of the oval being in the direction of the prevailing wind during the dissemination period. The wind does not "carry" the seeds in the ordinary sense. It reduces the distance to which the seeds are shot against the wind by the ejective force and increases the distance with the wind.

Because of their mucilaginous covering, the seeds stick to whatever they strike. A good many may stick to twigs of the surrounding tree crown.

Germination and Growth

To start a new infection the seed must become attached to the bark of a young branch on a susceptible host. On germination the germ tube (radicle) grows along the bark surface until it is obstructed by a bud or leaf base. At this point the radicle produces an irregular mound of tissue which functions as an anchor. From the under side of this mound of tissue the primary root-like haustorium develops. If the bark is not more than 3 years old, the haustorium can penetrate it to the cambium. Sometimes the haustorium penetrates thin older bark. From this primary haustorium other haustoria develop in the bark, constituting a new infection from which the aerial parts develop.

Any individual seed can produce a plant of only one sex, depending upon the genes it possesses. Male and female plants occur in about a 50-50 ratio. Development of a new plant of seed-bearing age from time of seed germination takes from 4 to 6 years, depending on site and host species.

SYMPTOMS OF INFECTION

Plants.--The presence of dwarfmistletoe plants is the surest sign of infection, but if the shoots have dropped off, the small basal "cups" from which they came remain on the bark (fig. 2).

Cankers.--Slight to definite, more or less fusiform swellings or cankers usually develop on infected twigs and branches (figs. 1 and 2). A cut through an infected branch will show, especially under a hand magnifier, the yellowish wedge-shaped sinkers of the subsurface (endophytic) part of the plants (fig. 3).

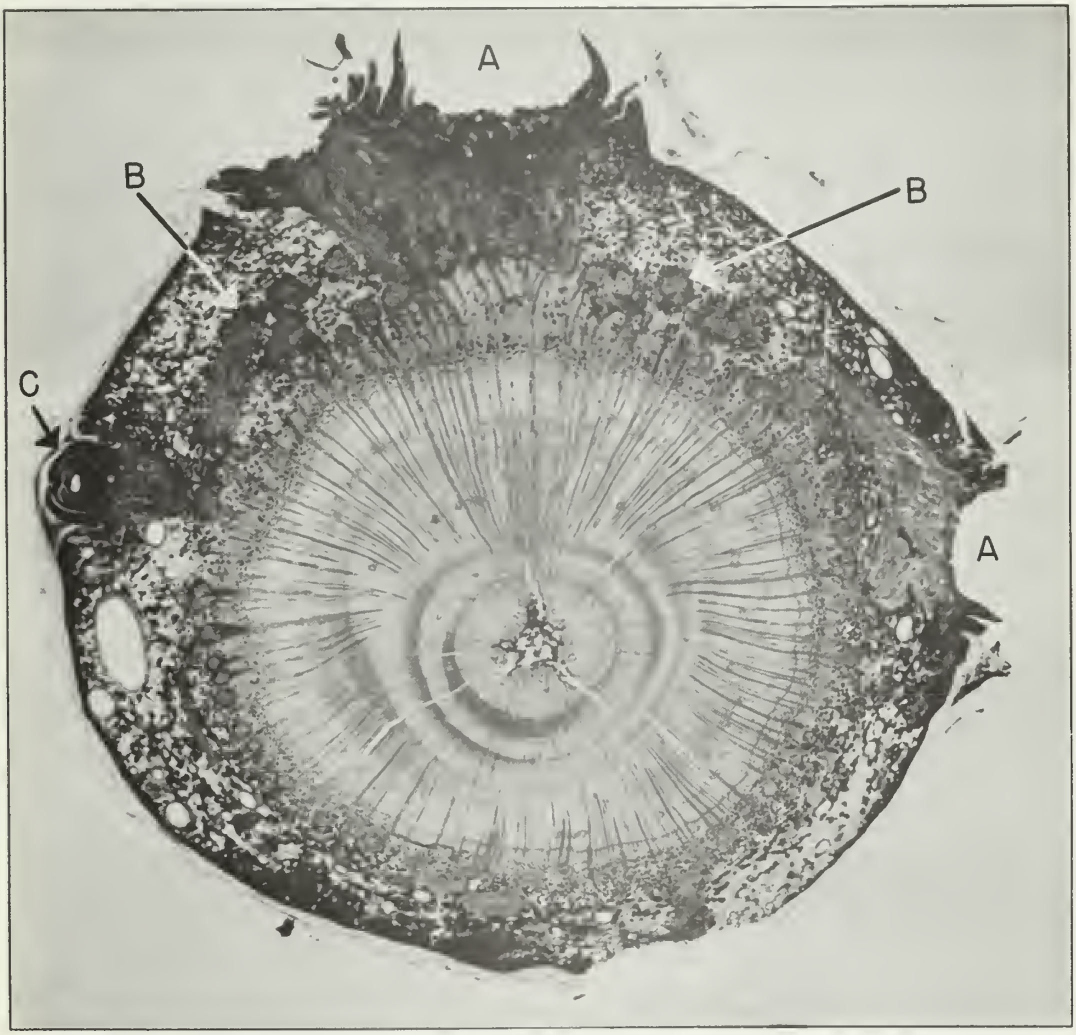

Figure 3.--Enlarged cross section of a pine branch infected with western dwarfmistletoe. A. Basal "cups" from which aerial parts of the parasite have dropped. B. Root-like haustoria in the bark from which dark, wedge-shaped sinkers originate and extend into the wood. C. A new dwarfmistletoe bud breaking through the surface of the host bark.

Witches' brooms.--Witches' brooms, which are proliferous growths of branches (fig. 4), are common in infected trees of Douglas-fir, western hemlock, ponderosa, sugar, and lodgepole pines. Brooms are less common on other tree species. Abnormally enlarged or swollen branches usually occur even where brooms are lacking.

Flags.--Large numbers of dwarfmistletoe-infected branches in red fir stands are killed each spring by a fungus (*Cytospora abietis*) which invades the dwarfmistletoe swellings. The foliage of these dead branches turns brick red, making conspicuous "flags" which persist throughout the year. This branch killing is much more common on red fir than on other tree species.

Trunk swellings.--Large spindle shaped or fusiform swellings, or flattened cankers, commonly occur on infected trunks of red and white firs and may occasionally be found on other species. Such swellings or cankers are rare on Douglas-fir.

Other symptoms.--When the lower crown is heavily broomed, spike tops may occur in older trees, especially in Douglas-fir and western hemlock. The foliage of infected trees is reduced except in broomed portions. Thin crowns and shortened and lighter colored needles are often symptoms of dwarfmistletoe infection.

Light to moderately infected stands are not readily distinguished from healthy stands except by the presence of such symptoms as cankers, brooms, or flags. Heavily infected stands on the other hand give the appearance of poor site conditions. They contain deformed, stunted or dying, and dead trees. Many white and red fir trees in heavily infected stands are broken off at bole cankers (fig. 5), and the stands have many small to large openings caused by the breaking up of the crown canopy by dead and broken trees.

DAMAGE

Dwarfmistletoes cause extensive, although not always spectacular, damage in California coniferous forests. Trees of any age may be retarded, deformed, or killed. Mortality is particularly heavy in Jeffrey pine seedlings and saplings and in red fir of all ages. Some young stands of Jeffrey pine may be so heavily infected as to be practically worthless, and in some areas red fir may be eliminated as a stand component. Many red and white firs break off at bole infections where decay has developed in dwarfmistletoe cankers and weakened the trunk (fig. 5).

In surveys of lodgepole pine dwarfmistletoe in the Rocky Mountains, the intensity of infection is classed as light when less than one-third, moderate when one-third to two-thirds, and heavy when more than two-thirds of the trees in the predominant size class are infected.

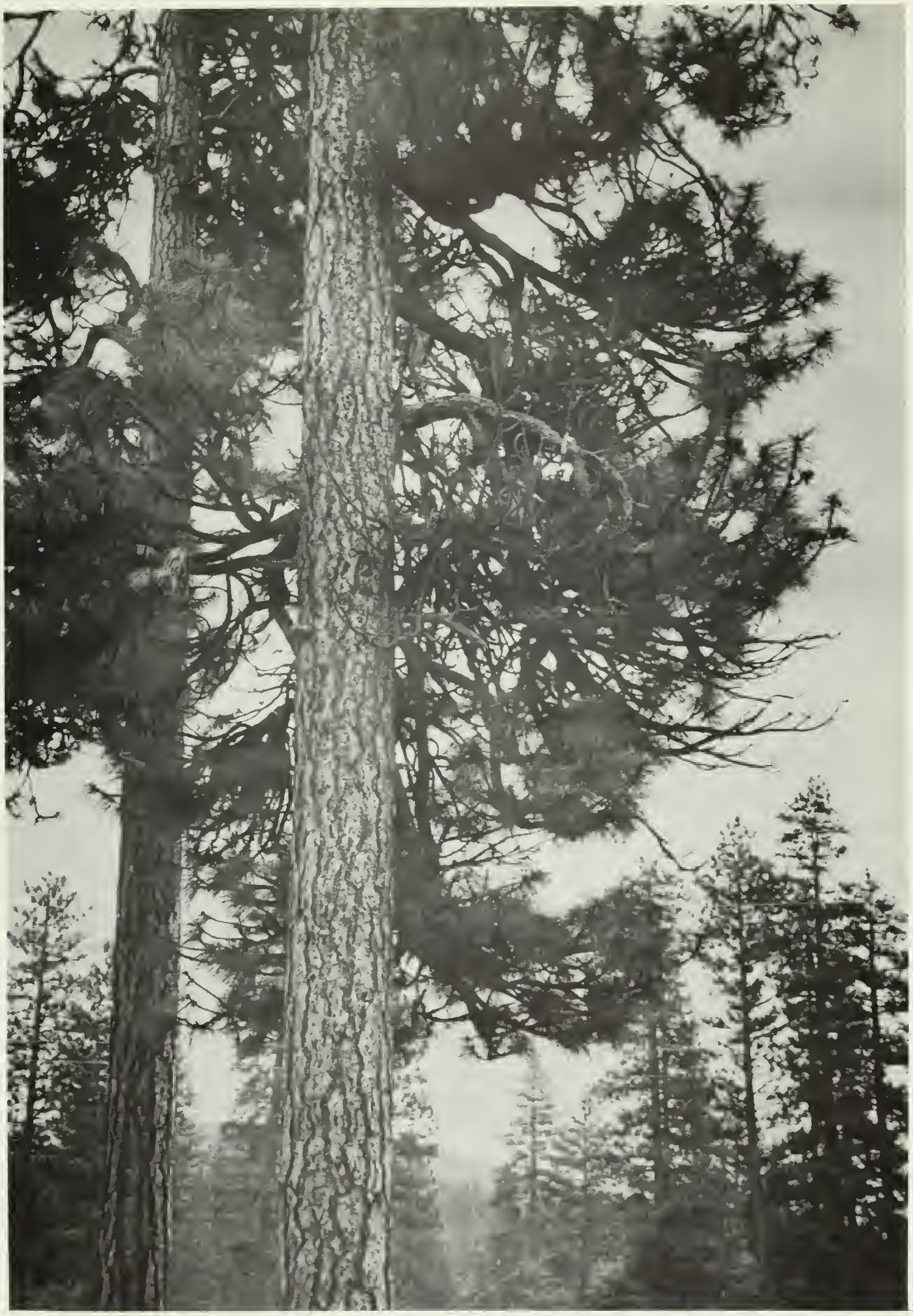

Figure 4.--Witches' brooms, caused by dwarfmistletoe, in the lower crown of a ponderosa pine.

Growth reduction.--Dwarfmistletoe reduces tree vigor. Height growth of Douglas-fir may be reduced as much as 49 percent and diameter growth of ponderosa pine as much as 72 percent in some heavily infected stands. In Arizona cubic-foot increment was reduced by 89 percent in a heavily infected stand of ponderosa pine, while a moderately infected stand was reduced 75 percent, and a lightly infected stand by 41 percent.

Quality reduction.--Dwarfmistletoe affects both quantity and quality of merchantable timber. Quality is reduced by numerous large knots and by abnormally grained, spongy wood that is frequently stained, pitchy, or decayed.

Seed reduction.--Seed production may be drastically reduced in heavily infected stands. Studies in Arizona have shown seed reductions as great as 75 percent in ponderosa stands. Quality of the seed is also affected. Jeffrey pine seed from dwarfmistletoe-infected trees was 20 percent lower in germination and produced less vigorous seedlings than seed from uninfected trees.

Other hazards.--Heavy dwarfmistletoe infection predisposes trees to attack by bark beetles, wood decay, and root diseases, as well as windthrow and breakage (fig. 5). Large dwarfmistletoe brooms, especially the dead ones, are a fire hazard, particularly promoting crown fires.

CONTROL POSSIBILITIES

There is nothing complicated about the control of dwarfmistletoe. The parasite can be eliminated from a stand by cutting or pruning all infected trees from seedlings to mature trees. In some pure stands this may necessitate clear cutting in blocks, and if the resulting blocks are too large, artificial regeneration may be required. However, in the mixed-conifer type it usually means at the most cutting all trees of one or two species. Subsequent artificial regeneration would not be necessary unless it is desired to reproduce the species removed. Manipulations of the tree species in a stand may at times be the most practical means of control. Since opening up a stand stimulates growth of dwarfmistletoe on the remaining infected trees, it is necessary to eradicate the parasite completely to effect control.

Dwarfmistletoe may be controlled on relatively small areas because its distance of spread is so limited. This means that the spread of the parasite into uninfected stands can be prevented, for all practical purposes, by maintaining a protective zone free of the parasite between the diseased stand and the stand to be protected. This zone may be cleared of all trees; it may be an established right-of-way or a stream; or it may be a strip in which only the susceptible tree species have been removed. To maintain a protective zone in which susceptible trees

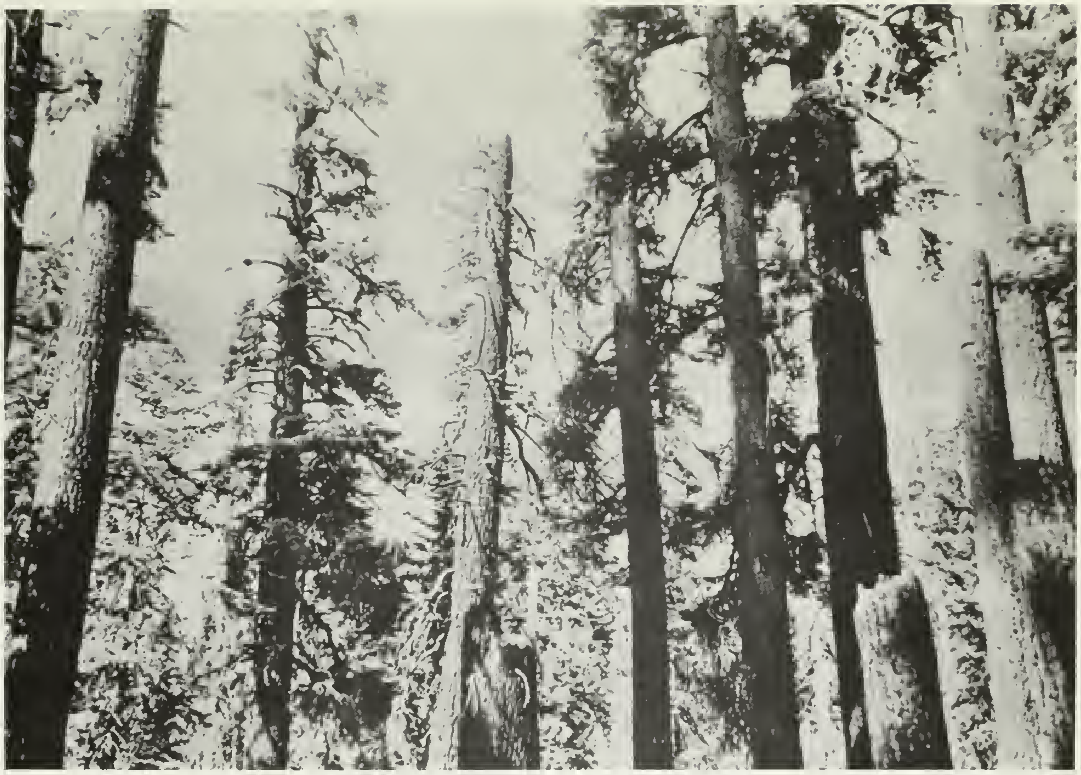

Figure 5.--Old-growth stand of red fir breaking up from heavy infection of dwarfmistletoe. Note many dead and broken trees.

occur would require constant vigilance for and eradication of new dwarfmistletoe plants. Therefore all protective zones should be completely free of the host tree that is being protected.

Only actively growing female dwarfmistletoe plants produce seed and are able to spread the disease. Male plants or old inactive infections need not be removed to prevent spread. Other than the capacity to spread the disease, however, all plants are equally able to damage the host trees.

Dwarfmistletoe often is eliminated where large forest fires have killed extensive timber stands. When natural regeneration in such burns comes from a distance rather than from an overhead seed source, or when the burned area is artificially regenerated, the resulting stands are usually free of the parasite. Conversely, when stands have been protected from fire for long periods, dwarfmistletoe becomes more abundant and damage more prevalent.

Biological agents sometimes affect dwarfmistletoe to a minor extent. Rodent chewing of cankered branches and parasitism by insects and fungi, although frequent, are of no practical significance in controlling dwarfmistletoe.

Control of the parasite by chemical spray or tree injection has possibilities, but research now being conducted has not yet revealed a satisfactory means of control.

Resistance to dwarfmistletoe is occasionally indicated by individual trees. There is a definite possibility that resistant strains could be genetically produced for many of our commercial conifers.

RECOMMENDED CONTROL PROCEDURES

After a control area has been delineated on the ground, the first step should be to eliminate the overhead source of infection. All infected trees of sawlog size should be removed unless it is desirable to retain those from which the infections can be removed by pruning. In recreation areas it may even be desirable to leave non-seed-bearing mistletoe infections.

After the overstory has been cleaned, all dwarfmistletoe infections in the pole stands and advanced reproduction should be eliminated in commercial timber areas and at least the seed-bearing dwarfmistletoe plants in other areas. Witches' brooms, although much more conspicuous than ordinary infections, are usually less important as seed sources than the less conspicuous thrifty, younger infections.

Three years after the first cutting and pruning the area should be carefully reworked to remove dwarfmistletoe plants that have subsequently appeared. After that, examinations should be made periodically at about 5-year intervals to detect and remove any new infections in order to prevent dwarfmistletoe from again spreading into or building up in the area.

Protective zones should never be less than 50 feet wide, even on level ground. If the host trees in the diseased area are more than 50 feet tall, the zone should be at least as wide as the height of the tallest host tree. On a slope where the diseased trees are above the protective zone, one foot should be added to the zone width for each degree of slope.

Dwarfmistletoe control in immature stands may often be incorporated in thinning and crop-tree pruning operations. Branch infections that have not yet grown into the main bole may be removed from a tree by cutting off the branch. If the distance from the swelling (or other indication of infection) to the base of the branch is greater than twice the branch diameter, the infection may be pruned out by cutting off the branch flush with the tree bole.

Bole infections cannot be satisfactorily cut out; therefore, trees thus affected must usually be removed.

The best time for control is in the late summer just before the berries mature, and when the maximum number of young shoots can be detected. Timber felling should be avoided during the seed dissemination period, if possible, to prevent unnecessary spreading of the seeds.

CONTROL COSTS

Costs of control measures now recommended vary with the intensity of infection, the age and composition of the stand, and the size of the infected areas involved.

In sawtimber stands the costs will depend largely upon the amount of dwarfmistletoe infection remaining after the harvest cut and the extent of artificial regeneration required. Costs will be less in lightly infected stands and in pure stands of even-aged old-growth timber where clear cutting in blocks is practical.

Control costs will be greater in pole stands and other immature stands where trees to be cut are not merchantable. Should a market be developed for material from immature stands, control costs would be reduced significantly.

To minimize costs, stand units to be clear cut should have a low ratio of perimeter to area. Large compact areas approaching a circle or square are most desirable. Narrow strips should be avoided to minimize reinfestation of the sanitized area from the uncut perimeter. This will reduce costs of obtaining and maintaining infection-free reproduction.

Forest managers are urged to keep cost records on all their dwarfmistletoe control projects so that cost data may be accumulated for California conditions. We especially need more information on the practicability and cost of control on areas of varying size.

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